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Performance evaluation of 4-stroke gasoline engine using Bio fuel (Ethanol)

A Rafeh¹, K Obaidullah², A Masih¹ and A Rehman¹

¹Ural Federal University, Ekaterinburg, Russia

²University of Engineering and Technology, Taxila, Pakistan

E-mail: adven.masikh@urfu.ru; abdul.rafe@urfu.ru

Abstract. The article examines the performance of a 4-stroke gasoline engine using Bio-fuel (Ethanol). The research work was carried out on a SOLTEQ engine test bed available in university in Thermodynamics laboratory. In this study an ordinary gasoline engine was fixed on test bed. Several modifications to external parts of the engine were made to fix it on the bed such as base frame, suction port, exhaust port and oil temperature indicators. To asses engine performance the experiment setting used gasoline with 5 different blends of ethanol such as E0 (100% gasoline), E5 (95% gasoline, 5% ethanol), E10 (90% gasoline, 10% ethanol), E15 (85% gasoline, 15% ethanol) and E20 (80% gasoline, 20% ethanol). While the engine performance was evaluated at operating parameter called wide open throttle (WOT). Different charts were established to compare results. The results obtained from analysis showed significant deviations in performance curves at different fuel grades. These results were quite useful especially for utilizing ethanol additives with gasoline in ordinary gasoline engines.

1. Introduction

Alternate fuel has been a topic of research in science and engineering for a long time. At present under experimental and numerical study of internal combustion (IC) engine behaviour on ethanol fuel, a wide-ranging research from different angles has been carried out and published in different literatures of engineering world. The global production of bio-ethanol has increased from 17.25 billion litres in 2000 to over 46 billion litres in 2007 [1]. In 2007, bio-ethanol production represented only 4% of the 1300 billion litres of gasoline consumed globally. However different estimates from government programs in America, Asia, and Europe suggest that the total global bio-ethanol demand could reach upto 125 billion litres by 2020 [2].

Literature review conducted in the context of this work revealed that a significant performance improvement and emission reduction in the small engines can be obtained if the engines with low compression ratio could be run at higher compression ratios using alternative clean fuels resistant to the knock [2]. Later, the idea was further extended on by the resrahers [3] who state that torque, brake mean effective pressure (BMEP) and output power of an engine are substantially improved by increasing compression ratio at high speeds for both, E22(78% gasoline, 22% ethanol) and hydrous ethanol. However, the specific fuel consumption of hydrous ethanol is higher than that of E22 in a flexible fuel engine. Considering the issue of combustion and emissions behavior for ethanol-gasoline blends, work by [4-6] proved that, at constant mass fuel rate, gasoline blended with 10% ethanol has marginal effect in combustion rates relative to the reference fuel. While for 20% ethanol, the combustion process slows down and increases cyclic dispersion in proportion to the burning rate reduction. Furthermore, Masum



et.al [5] studied the effects of ethanol–gasoline blend on NO_x emission and recommended that pure ethanol fuel is not suitable for engine cold-start [7]. Engine can easily start in cold condition with lower HC, CO and NO_x emission with use of ethanol blended gasoline fuel than gasoline. Other notable findings of work include: Un-burnt HC emissions are maximum for ethanol–diesel blended fuels and minimum for ethanol–water blends; CO emissions are maximum for ethanol–gasoline flames and minimum for ethanol–diesel flames.

The purpose of this study is to examine the engine (4-stroke gasoline) performance using gasoline and different blends of ethanol. Engine output parameters will clarify the performance characteristics of each fuel. The effect of ethanol addition to gasoline in various concentrations on engine performance is evaluated by conducting experimental studies. To determine the engine performance on WOT using Ethanol blends in a gasoline engine at normal operating conditions.

2. Materials and methods

This SOLTEQ Engine Test Bed (Model: TH 03) is a self-contained compact unit designed for easy installation and bench mounting. A DC motor is used as a dynamometer to load the engine and dissipate the power in a resistive load bank. The motor comes with manual control of the load. The test set is supplied with, as standard, a Robin engine. To carry out this research work, the engine was replaced with an alternate 4-stroke, spark ignited, air cooled, side valve type single cylinder gasoline engine (Honda GX 120) as shown in figure 1. The engine and dynamometer are installed on a solid steel base plate temporarily mounted within a steel framework. The instrumentation and control panel are mounted on the front frame. The engines are supplied with proper adaptors for measuring of temperature at inlet, exhaust, and fuel and lubrication oil tank.

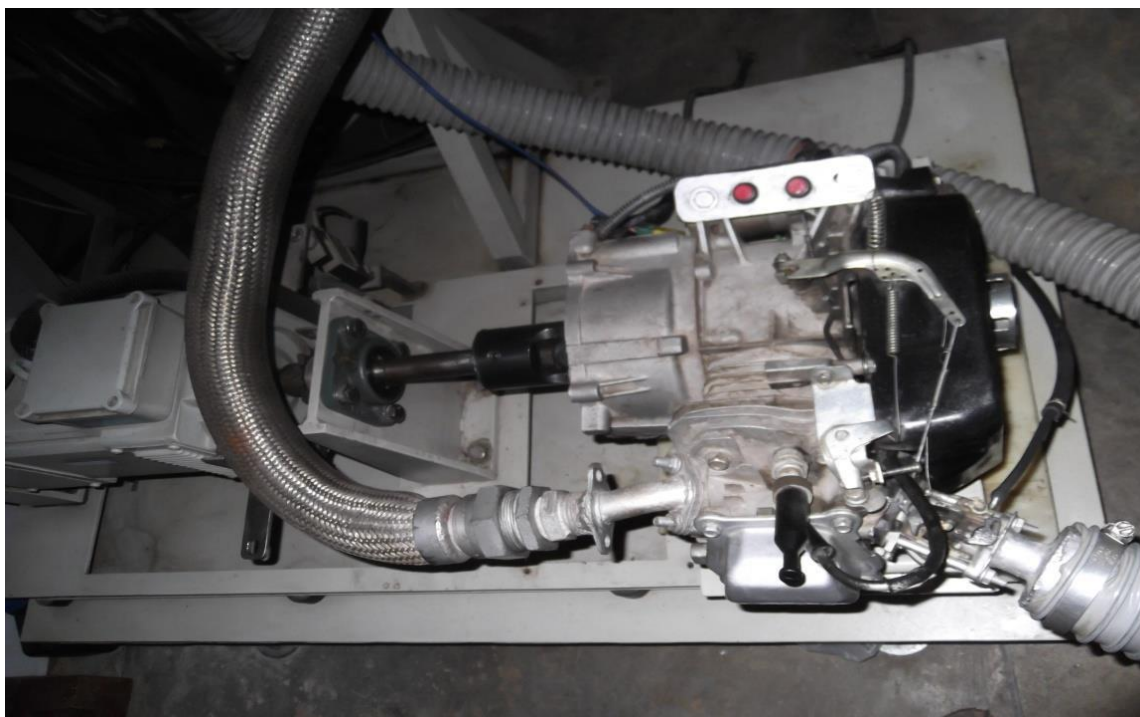


Figure 1. Assembly of 4-stroke engine and SOLTEQ Engine Test Bed

The experiments are carried out using different blends of ethanol with gasoline. The list of five different fuel blends used for experiment analysis is as follows:

- E0 (Gasoline 100 % Unleaded)
- E5 (95 % gasoline and 5 % ethanol)
- E10 (90 % gasoline and 10 % ethanol)

- E15 (85 % gasoline and 15 % ethanol)
- E20 (80 % gasoline and 20 % ethanol)

Ethanol-gasoline blending is carried out on the basis of volume-volume percentage. 200 ml of blend for each type of fuel is prepared for each experiment.

3. Results and discussion

The performance of IC engine is characterized with several geometric and thermodynamic parameters listed below.

1. Speed (RPM)
2. Torque (Nm)
3. Electrical power Output (Watt)
4. Brake Power (kW)
5. Load Applied

Table 1. Wide open Throttle results

	Speed (RPM)	Voltage (V)	Current (A)	Torque (Nm)	Electrical power Output (Watt)	Brake Power (kW)	Load Applied
E0	2943.16	391.63	4.96	19.05	1943.85	5.86	700
	2282.1	301.7	4.83	18.63	1456.92	4.44	900
	1525.28	200.8	4.28	17.8	860.52	2.84	1200
E5	2995.02	402.4	5.08	21.56	2044.26	6.75	700
	2264.73	302.16	4.85	21.25	1465.61	5.03	900
	1874.48	248.2	4.9	21.24	1216.36	4.16	1100
E10	3031.68	409.8	5.16	21.54	2114.64	6.83	800
	2165.46	289.2	5.16	21.38	1492.36	4.84	1100
	1519.73	200.6	4.62	20.6	926.433	3.27	1400
E15	3093.62	408.6	5.16	21.38	2108.46	6.92	700
	2259.94	296.2	5.32	21.34	1575.86	5.04	1000
	1635.48	211.6	4.9	20.82	1037.06	3.56	1300
E20	3053.55	408	5.23	21.21	2134.2	6.78	700
	2150.4	284.2	5.08	21.06	1443.98	4.74	1000
	1732.18	228	4.88	20.65	1111.62	3.74	1200

The detailed results of the experiment are presented in table 1. It shows a smooth behavior of IC engine using fuel 100 % gasoline at WOT as shown in table1. Electrical power output is round about 2000 watt at maximum throttle and torque is just above 19 Nm at maximum Rpm. In both cases a constant drop in engine electrical power output and engine torque is observed with the reduction in engine speed. Engine speed reduction is obtained by grounding the output engine current. 700 watts load is applied initially to achieve WOT of engine.

A significant increase in engine electrical power output and engine torque is observed by the addition of ethanol to gasoline by 5 % (E5). 700-watt load is applied to achieve WOT .Figure 2 also indicates WOT engine electrical power increased from that of using pure gasoline. Engine torque jumped to 21.5 Nm and electrical power to more than 2000 watts at same operating conditions.

A considerable change in engine performance is observed at WOT condition when E10 is induced. Initially 700 watts loads is applied to attain WOT condition Figure 2 further illustrates that initially 800 Watts of electrical load is applied to attain 3000 RPM at WOT instead of 700 watts as in case of previous experiments. Electrical power and engine torque increased to 22 Nm and 2100 Watts respectively.

Engine operation was also observed to be very smooth at this particular fuel blend. Considering the engine parameters at WOT using fuel E15, an uneven trend is observed in Engine torque Vs speed (figure 2). Torque increased with the decrease in engine speed to a maximum value of 21.66 Nm at 2500 rpm but again reduced with further reduction in engine speed. Anyhow engine electrical power output trend remained smooth with a maximum value of 2100 watts almost similar to that of E10.

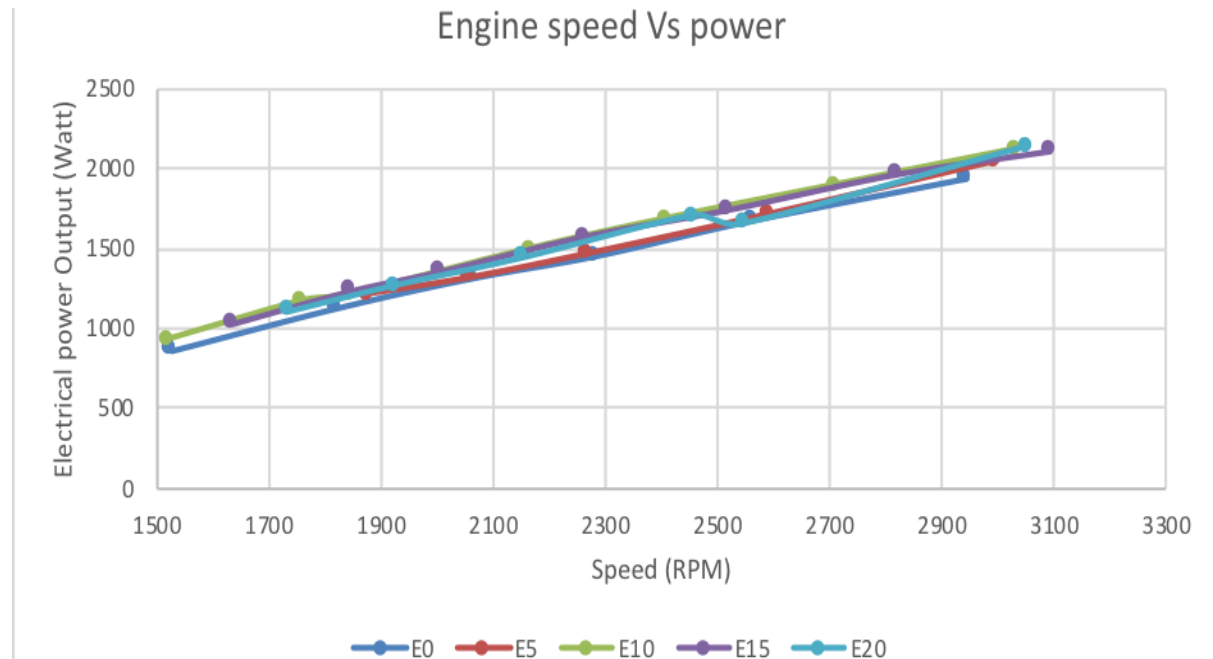


Figure 2. Engine Speed Vs Electrical power at WOT comparisons

Finally, E20 results reflect that maximum values of electrical power and torque are similar to those of previous blends but there are various irregularities of parameters at each load condition. For example engine electrical power output and torque dropped to 1657 watts and 19.65 Nm respectively at 2500 RPM but a sudden increase in same parameters was observed at 2400 RPM as 1706 watts and 21.23 Nm. With further decrease in engine speed more uneven engine behavior was observed at all loading points. Physically increased engine vibration is seen at this experiment.

It was observed that the increase in ethanol blends is increasing the water contents in fuel which affects combustion, which proves that the higher ethanol containing fuels are not suitable for IC engine designed for gasoline. The experiments were therefore ended up with E20. The comparison of engine speed Vs electrical power curves for all the fuels at WOT. All ethanol blends (E5, E10, E15 and E20) have shown an improved performance behavior then gasoline at WOT, E5 trend is closer to gasoline curve. E10 and E15 are following the same trend and at the top of all other curves (figure 2). Although E20 has several irregularities in behavior, however, higher values of electrical power output have been observed in all ethanol blends as related to gasoline.

Similar behavior of all ethanol blends is observed at WOT when computed the brake power of engine as shown in figure 3. Significant improvement in engine brake power is observed in all ethanol blends (E5, E10, E15, E20) related to gasoline compared on the basis of engine speed. All ethanol blends have higher values of brake power than gasoline. E5 has much lower brake power than E10 and E15 at higher engine speed but at low engine speeds a gradual improvement is observed. E10 and E15 have leading trends on the graph while E20 lies in between gasoline and all other ethanol blends.

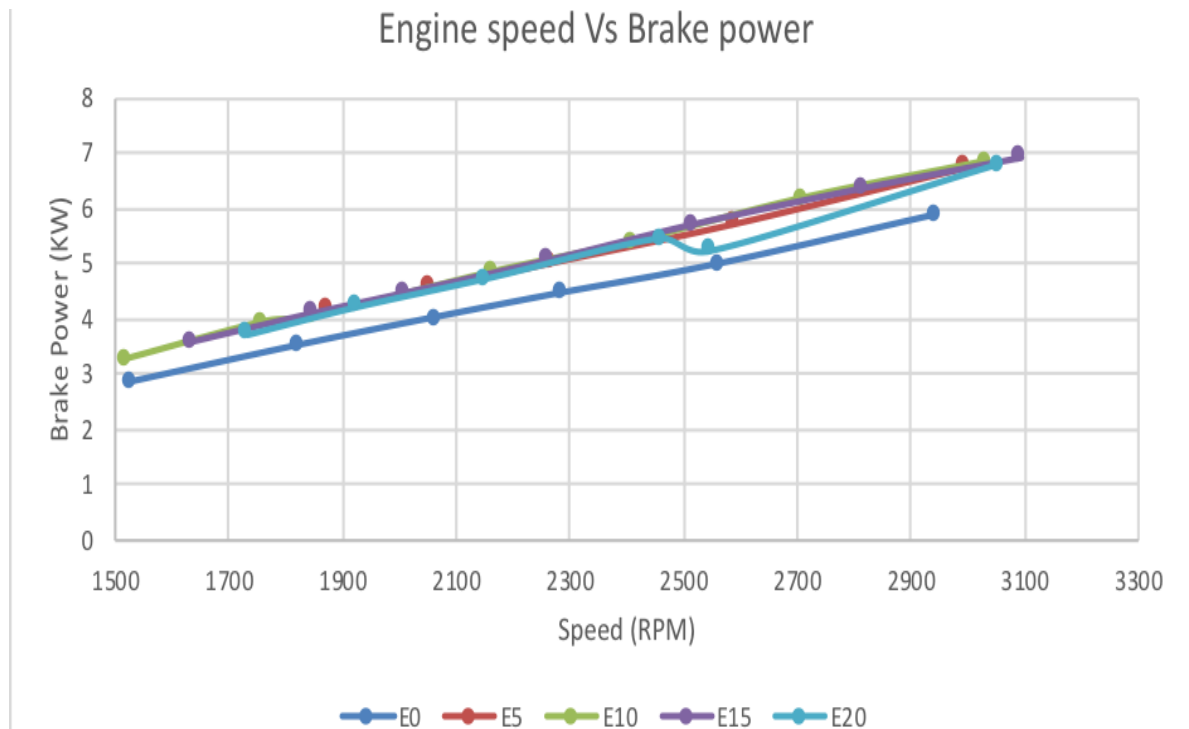


Figure 3. Engine Speed Vs Brake Power at WOT Comparisons

4. Conclusion

The main objective of this work is to evaluate the performance of IC engine using gasoline and different blends of ethanol and to indicate the optimum blend of ethanol which gives the best results for this compression ratio. The tests are conducted in order to investigate the performance parameters of engine. Ethanol blends up to E20 can be used as a fuel for 4-stroke Spark ignition gasoline engine without altering the compression ratio of Engine. Higher blending percentage of ethanol is not recommended as the higher water content in the fuel disturbs the combustion process. As a result, engine performance as well as operation is not stable. Higher grades of ethanol require a modification in engine compression ratio and hence they are not suitable for 4 stroke SI engine designed for gasoline. All ethanol blends Improved engine Electrical power output and Brake Power at WOT. Similarly improved Electrical Power output, Brake Power and BMEP is observed on ethanol.

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